INVESTIGATION ON SOIL CONSERVATION AND SOIL STABILITY WITH GEOGRID IN THE ARID AND SEMI ARID AREA (VARAMIN-IRAN)

Kaveh Khaksar[1] – Saeid Haghighi

[1]Islamic Azad University, Rud-Hen branch, Mojtameh Daneshghy, Department of Civil engineering, Rud-Hen City-Iran, 0098 912 1041693, Fax: 0098 261 6700876, E-mail: kavehkhaksar@gmail.com

1. Abstract

Slope stabilization can be done using geogrid. In steep slopes, regeneration of vegetation is very difficult. The usage of geogrid in slope over 85% can be successfully technically and economically. To determine polymer net works, plots of 12×2 meters were constructed. They were enclosed with steep plates; runoff and sediments gathered and were led to gathering plots. Different treatments were considered for the research. Two slope (85% & 110%) and there replication were among the treatments 9 events were recorded. These data were analyzed in SPSS software. We concluded that there is significant difference in plots conducted in 110% but there is no significant difference in slope 85%. Different treatments along with replications were chosen. Nine events were measured. Totally plots where in geogrid were used, soil degradation shows lower rate. Conclusions and analysis proved that it is very economic compared to other treatments. So geogrid can be used with great success in arid and semiarid areas.
KEYWORDS: Erosion control, Geogrid, Slope stability, Soil conservation, Arid and semi arid area.

2. Introduction

Geosynthetic have been widely used in erosion control applications. The growing attention to the problems of Environment Impact has allowed a fast development of the geosynthetics used for erosion control and revegetation of arid areas, slopes, road embankments, etc.

Erosion has always been one of the major sources of damage to both the natural environment and the man-made structures. Erosion is caused by different factors and can be avoided only if protection measures are properly selected according to its cause. Erosion on slopes may be caused by rainfall, runoff or wind.

Geogrid are nowadays widely used for erosion control on slopes. In many cases the soil of a slope is rocky or totally arid, due to the lack of organic materials in the soil matrix. This situation often occurs when cutting a road slope, or in quarry areas or generally in rather dries regions. In this condition a minimum top soil layer of 70-100 mm is required to be laid on the arid soil for the vegetation to be successfully established on the slope. But top soil has low geotechnical characteristics and can easily slip down along slopes with an inclination greater than 30°, or it can be deeply eroded by heavy or sustained rains occurring prior to grass growth.

Geogrids provide stability to the top soil layer through confinement: once extended to their full open size and filled with lightly compacted top soil, a stable and inextensible planting medium is achieved. Slopes with different length, inclination, soil characteristics, can be properly protected against erosion by the choice of the most suitable kind of geogrid. Geogrids have junctions that allow the passage of water between adjacent cells (Khaksar et al., 2007).

Rainfall erosion occurs mainly on bare slopes, while the vegetation provides the natural and best protection: in fact the rainfall erosion is caused by the splash of the rain drops which detaches and displaces the soil particles, making them available for transport by gravity and surface runoff. A dense vegetation cover both absorbs the impact energy of the rain drops and ties the surface soil granules through the roots network. Hence, the best way to protect a slope from this kind of erosion is to establish quickly a dense and uniform grass cover. The stability of the surface layer of topsoil allows the seeds to germinate quickly and the vegetation to uniformly cover the slope. While growing, the roots intertwine with the geogrids, thus creating a natural-synthetic network with a much higher resistance to the shear forces than the roots alone.

This paper is derived from a research on slope stabilization using Geogrid in the arid and semi arid areas of Varamin region in southeast of Tehran. The objective was to study the efficiency of geogrid materials in technical and economical aspects for high slope stabilization and decrease of soil erosion. The results could be applied for stabilization of slopes next to dam reservoirs or trenches resulted by road construction. It shows that they can present soil degradation and soil erosion plots of 12×2 meters were chosen in the research. At the end of plots, runoff is caught and measured and sediment amount in the runoff was measured. Different treatments along with replications were chosen (Table 1). The overlaps are made by superimposing the two outer strands of the geogrid layers and fixing them with "U" shaped staple every approximately 2 m.

Table 1 Different chosen treatments

A	Geogrid with natural grassland covering
B	Geogrid with seeding aboriginal grassland species
C	Without geogrid and with natural grassland covering
D	Without geogrid with seeding aboriginal grassland species

The combined use of geogrids, for stabilizing a thick topsoil layer, and of geomats, for surface protection, provides the most effective erosion control system in heavy situations Maccaferri Pty Ltd (2005) assisted in the design of reinforced soil wall using Maccaferri gabions and RockGX geogrids. This system was chosen because of its ability to blend into its natural environment. For the critical section, measuring approximately 5 m in height, soil reinforcement in the form of polyester geogrids was used to create a stable reinforced soil block mass. The Rock GX geogrids were laced between adjacent gabion baskets, providing superior long-term design strengths. Eden Gardens garden & nursery centre have provided their customers and workers an environmentally friendly and naturally looking environment. Revegetation and landscaping of the gabion garden walls is simple and effective.

2.1. Study area

The Varamin basin is situated in the 60 km south eastern of Tehran province in the northern part of Iran, in the latitude 35º 24′ 31″ N and Longitude 51º 55′ E situation (Figure 1).

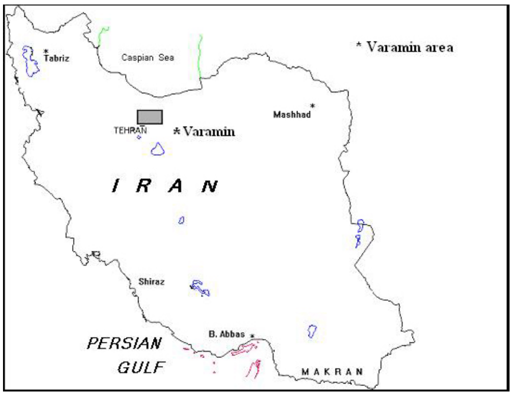

Figure 1 Location of the study area

The topography of the study area varies from plain to mountainous and includes old to young geological formations. The climate of the Varamin catchments is arid to semi arid, although locally the climate varies due to the altitude. There are four kinds of meteorological stations; rain gauge and evaporation station. The all of stations record the amount of precipitation, air temperature, relative humidity and amount of evaporation from class A pans. The mean of annual precipitation rate is 185.7. Mean maximum temperatures during 1990-1997 range from 29.9 to 39.9 Cº and mean minimum ranges from -1 to 6.6 Cº January is the coldest month while August is the warmest month in the study area. The mean of annual temperature rate is 16.1 Cº. Temperature regime of area is thermic.

The Varamin catchment's is situated in the southern slopes of the Alborz range and existed different geological formations, but the project has been effectuated on quaternary alluvial fan. Area is no soil cover because the project is doing in the Quaternary alluvial fan with high slopes, the soil is classified to Course loam with Ap (platy) structure and brown inclined to clear yellow in color and with sandy texture and mass structure with calcareous fiber. There is a thin layer of soil, which is classified to: lithic leptosols, calcaric regosols and gypsic regosols. In the studied area due to non-existence layer of soil, the vegetation covering is weakly and predominate vegetal species are: *Salsola kali* and *Pteropyrom olivieri*. In the study area the drainage network consists of ephemeral and perennial streams. Because of the arid climate, most streams are ephemeral. Runoff flow after each rain falls largely disappears in the Quaternary surface depositions. There are some perennial rivers in the study area with North-South directions.

3. Methods

Characteristics of used geogrid: Several different solutions were discussed, designs and calculations were carried out and the most economic solution was to use the locally available recycled material with a pH value of 11.5 and integral geogrids. The recycled material needed a high chemically resistant reinforcement with a low factor of safety against installation damage. Placement of the geogrid panels: Geogrid panels shall be expanded to the full open dimension, parallel to the flow direction. Each panel shall be first anchored at the top of the slope in a trench whose dimensions are determined by design. If it is possible, the anchorage trench at the top can be filled with concrete (to reduce the embedded length).

Along the slope the geogrid shall be anchored with pins. The spacing between the pins shall be determined by the design engineer. Pins have shape and length depending on the soil characteristics. Pin diameter shall be 8 mm minimum. Each pin shall be placed at the junctions of the panel. The geogrids can accommodate infill and finishes such as soil/grass, gravel.

In this investigation has been measured geogrid efficacy in aspects of technique and economic in soil stability and decrease of soil erosion in the steep slope and collected data has been analyzed. In this investigation the geogrid with bellowed characteristics to soil conservation and soil stability (Table.2) has been used.

Table 2 Characteristics of used geogrid

Aspect	nets or grids in rolls or boxes
Solubility in water	insoluble
Polymer	Polypropylene-HDPE
Ecotoxicity	Non toxic.
Measure	690 g/m^2
Measure of gates	27×27 mm.
Tensile strength	8.5 Kn/m
Applications	Stabilization and reinforcement of weakly soils

Nine events were measured. The data were analyzed with the Spss program. The results showed in both slope types: a) in the 110% slope the erosion was much more than the 85% slope b) the treatment plots which were stabilized with geogrids. Conclusions and analysis proved that it is very economic compared to other treatments. In the study area, the erosion situation in the alluvial soils has been evaluated. The quantity of raining in the seventh event had been more than other events. The least rain event 4.5 mm had been related to second event. The most number of runoffs also related to ninth event which in the respect of other runoff events it has been the most in all of plots. Least runoff event belongs to second event. The receipted data has been analyzed with Spss program. The effect of slope and soil covering of plots, also their reciprocal effects to amount sediment concentration has been evaluated (Table 3) with two way on variance analysis.

Table 3 Two way variance analysis
Tests of Between-Subjects Effects

Dependent Variable: log of s Dependent Variable: LOG

Source	Type III Sum	df	Mean Square	F	Sig.
Corrected Model	3.014(a)	7	.431	1.992	.120
Intercept	.101	1	.101	.468	.504
SLOPE	.426	1	.426	1.971	.179
COVER	2.442	3	.814	3.766	.032
SL * CO	.146	3	490	.226	.877
Error	3.458	16	.216		
Total	6.574	24			
Corrected Total	6.472	23			

a R Squared = .446 (Adjusted R Squared = .204)

Table 3 indicates that slope has not effect on amount of sediment concentration with %95 probability but difference of sediment concentration logarithm quantity in different soil covering has been significant in surface of %3.

Table 4 Multiple comparisons between different groups
Multiple Comparisons Post Hoc Tests

Dependent Variable: log of s

LSD (I) covered	(J) covered with	Mean Difference	Std. Error	Sig.	95% Confidence Interval	
					Lower	Upper
A	B	.0303	.25915	.908	-.5103	.5708
	C	-.5981(*)	.25915	.032	-1.1387	-.0575
	D	-.6436(*)	.25915	.022	-1.1842	-.1030
B	A	-.0303	.25915	.908	-.5708	.5103
	C	-.6283(*)	.25915	.025	-1.1689	-.0877
	D	-.6738(*)	.25915	.017	-1.2144	-.1333
C	A	.5981(*)	.25915	.032	.0575	1.1387
	B	.6283(*)	.25915	.025	.0877	1.1689
	D	-.0455	.25915	.862	-.5861	.4951
D	A	.6436(*)	.25915	.022	.1030	1.1842
	B	.6738(*)	.25915	.017	.1333	1.2144
	C	.0455	.25915	.862	-.4951	.5861

* The mean difference is significant at the .05 level.

Mean type of soil covering has been influenced on sediment quantity, which with LSD test help (Table 4) with %95 probability this difference related to soil covering B type (Geogrid with seeding aboriginal grassland species) with sediment concentration average of 0.78 gr/liter and soil covering D type (Without geogrid with seeding aboriginal grassland species) with 3.9 gr/liter of amount sediment concentration. This is meaning that in the B plots sediment concentration is less and in the D plots is more than other plots. Also Table 4 shows that the together influence of slope and soil covering type with %95 of probability is not significant.

For evaluation of amount soil losses for Hectare, produced sediments has been extended to hectare. Importance of this subject for this reason is important that erosion and soil losses evaluation in the each area explain erosion situation and sensitivity to erosion of the area.

The quantity of sediments that each treatment can produce in each Hectare has been presented. The most of sediments produced related to plots without geogrid with seeding aboriginal grassland species have been most of soil losses. In the two another treatments: A and B (Geogrid with natural grassland covering and Geogrid with seeding aboriginal grassland species) the quantity of soil losses are very fewer than the others.

The results could be applied for stabilization of slopes next to dam reservoirs or trenches resulted by road construction. In the regards of produced results from this study, investigation of another researches and as well as full use of geosynthetic in soil stabilization (road trench and railway lines) and erosion prevention in the steep slopes (rivers and dam borders) has been suggested use of geosynthetic in the non structural manner in the soil conservation and slope stabilization.

4. Results

A total of 9 events resulted runoff and sedimentation. The data were analyzed with the Spss program. The results showed in both slope types: a) in the 110% slope the erosion was much more than the 85% slope b) the treatment plots which were stabilized with Geogrids indicated a lesser to no erosion. The computation results show that the lands with 110% slope have the erosion rate of 37.17 kg/ha./yr if stabilized with Geogrids and 1384.6 kg/ha./yr if not stabilized. For the land with the slope of 85% the above rates are 11.37 kg/ha./yr and 129.1 kg/ha./yr respectively. Geogrids are made of polypropylene resistant materials. Because of low price and not necessity to complicated installation equipments, these materials are more economical and reliable them the other less than stabilization methods.

Table 5 Comparison of geogrid application value with other methods for soil conservation

Type of applic.	Dimension of units (Dollar)	Number /hectare	Amount of unit/m^3 (Dollar)	Percent per geogrid application
Geogrid application	1$/$m^3$	For cover 50%	5000×1=5000 $/$m^2$	-
pitching and terracing	3×3×1	100 m	12.19 $/$m^3$	+219
Gabions	3×3×1	100 m	22.5 $/$m^3$	+450
Retaining wall	1 m^3×3 m height	100m/length	24.5 $/$m^3$	+490

Regarding to table 5, soil conservation in the steep slope soils with geogrid in comparison with other protective methods like to gabion, retaining wall, pitching and terracing decreased expenses respectively 450, 490 and 219 percent to hectare.

This investigation and other studies show that geogrid can establish the steep slope, suggest that the use of geogrid to issue in soil conservation and soil stability in the steep slopes (road trench and railway lines) and prevent erosion of rivers and dam borders . We can use different types of geosynthetics, because of low costs, high durability, high resistance and high suitability to environmental conditions. It shall be used according to the good work practices, protected with geogrids, while areas with long slopes and/or high runoff may require the use of without disposing the product in the environment. The polymer products are completely recyclable. The growing attention to the problems of Environment Impact has allowed a fast development of the geosynthetics used for erosion control and revegetation of arid areas, slopes, road embankments, etc.

5. References

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